# PATENT SPECIFICATION

(11) 1 249 725

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DRAWINGS ATTACHED

(21) Application No. 4507/69 (22) Filed 27 Jan. 1969
(31) Convention Application No. 700872 (32) Filed 26 Jan. 1968 in
(33) United States of America (US)
(45) Complete Specification published 13 Oct. 1971
(51) International Classification B 23 g 5/06
(52) Index at acceptance
B3N 5H12 5H6
B3H 2D

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## (54) SELF-TAPPING SCREWS

(71) We, ILLINOIS TOOL WORKS INC., a corporation organized under the laws of the State of Delaware, United States of America, of 8501 West Higgins Road, Chicago, Illinois 60631, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to self-tapping screws for use with thin sheet metal panels. Heretofore, screws have been provided with bulletnose-like points which have been designated gimlet points and usually have had widely-spaced threads for use in sheet metal. By application of axial pressure to such a screw, an aperture in a sheet metal panel is slightly deformed downwards by the gimlet point and the spaced threads grip the sheet material on opposite sides of the material or alternatively form partial threads in the aperture. Other forms of screws utilizing spade or shovel type points have been used to ream an aperture in sheet metal to accommodate a specific screw diameter which normally would not be accommodated due to tolerance variations, primarily on the low side.

The present invention provides self-tapping screws having a head, a threaded shank, and a work-penetrating portion at the end of the screw opposite to the head, the work-penetrating portion having two integral dissimilar segments falling on opposite sides of a plane coincident with the axis of the screw, the first segment being substantially one half of a tapering prolongation of the shank, terminating in a tip, there being a helical flute impressed in this first segment, this flute being of the same hand as the shank threads, and the majority of the flute being of greater pitch than the shank threads, the second segment having a first portion which extends from the tip of the work-penetrating portion through a distance less than the axial extent of the work-penetrating portion, and being substantially on or parallel to the said plane coincident with the axis of the screw, the second segment having a second portion which blends radially outwards and towards the head to the juncture of the work-penetrating portion with the shank, whereby the work-penetrating portion is substantially symmetrical when viewed perpendicular to the said plane, and is unsymmetrical in relation to the axis of the shank when viewed along that plane.

A screw having this configuration is capable of being utilized in an undersized hole in a sheet metal panel; the tapered point with its helical flute engages the edges of the aperture, and through rotation of the screw tends not only to draw the screw into the aperture but also to form the margins of the aperture downwards and to create an evxtrusion. The extrusion exposes more axial extent of material and hence provides a greater area for engagement by the threads of the shank. The second portion of the second segment may be provided with partial threads which also engage the wall of the extruded hole and further draw the screw into the hole for engagement of the threaded shank.

A basic object of the invention is to provide a screw which is capable of extruding an undersized sheet metal aperture without excessive pressures being applied axially to the screw and also without requiring excessive torque to drive the screw.

Another object of the present invention is to permit the use of fine machine threads rather than spaced threads on the shanks of screws used in sheet metal applications and hence increase the tensile forces required to pull such a screw, i.e. to strip the screw thread relative to its engagement.

A further object is to provide a screw wherein a self-drilling feature may, if desired, be incorporated in the tip to permit the screw to drill its own hole, enlarge the hole and extrude the metal surrounding the drilled aperture.

Further features of the invention which are advantageous but not essential are illustrated

[*Price 25p*]

by the examples shown in the accompanying drawings, in which:—

Figure 1 is a side elevation of a preferred embodiment of the present invention, viewed from the line 1—1 of Figure 4;

Figure 2 is a front elevation of the same screw rotated 90° clockwise, i.e. viewed from the line 2—2 of Figure 4;

Figure 3 is a rear elevation of the same screw, rotated 180° from Figure 2, and as viewed from line 3—3 of Figure 4;

Figure 4 is an end view of the work-penetrating portion of the screw looking towards the head;

Figures 5 to 10 are enlarged views of the work-penetrating portion of the screw shown in Figures 1 to 4 as it is introduced and rotated within a thin workpiece aperture showing the development of the extruded material adjacent to the workpiece aperture;

Figure 11 is a partial top view of one jaw of a pinch-point die set used to forge one segment of the work-penetrating portion, as viewed from line 11—11 of Figure 13;

Figure 12 is a partial side view showing the pinch-point jaw as viewed from line 12—12 of Figure 13;

Figure 13 is a partial elevation of the pinch-point jaw;

Figure 14 is a partial top view, from line 14—14 of Figure 15, of the mating jaw of the pinch-point die set used for forming a second segment of the work-penetrating portion;

Figure 15 is a partial elevation of this mating pinch-point jaw;

Figure 16 is a partial side view from line 16—16 of Figure 15;

Figure 17 shows a typical headed blank from which the preferred embodiment is formed;

Figure 18 is a perspective view of a second embodiment of the present invention;

Figure 19 is a partial elevation of the work-penetrating portion of the embodiment shown in Figure 18;

Figure 20 is a partial elevation of the work-penetrating portion as viewed from line 20—20 of Figure 19; and

Figure 21 is a partial elevation of a third embodiment of the present invention.

The screw 30 shown in Figures 1 to 4 includes a head 32, a threaded shank 34 and a work-penetrating portion 36. The head is provided with wrenching faces or recesses to accept a driver. The shank is threaded through a substantial portion of its length, preferably with machine threads, although spaced or sheet metal threads are acceptable.

The work-penetrating portion 36, which embodies the inventive concept, includes two segments falling on opposite sides of a plane coincident with the axis of the screw. Such a plane would be perpendicular to the surface of the drawing in the view shown in Figures 1 and 4 and would fall on the axis of the screw. It is indicated in Figures 1 and 4 by the line A—A. The first segment 38 is one-half of a tapering prolongation of the shank, generally triangular in axial cross-section, as seen in Figure 2, terminating in a tip 40 rounded to form substantially one-half of a hemisphere. Intermediate the axial extent of the segment 38 there is a helical flute 42 which has the same hand as the threads on the shank 34 but has a non-uniform pitch which is rather high at its lower extremity and is substantially equal to the pitch of the shank threads at the juncture of the work-penetrating portion and the shank. The flute 42 may take the form of an upwardly-facing shoulder, with a radially reduced portion in the part of the segment 38 falling between the flute and the threaded shank, as in Figure 21 at 42b, or alternatively can be defined as the lower wall of a deep groove as shown in Figures 1 to 10. In either case, the entire work-penetrating portion is forged or pinch-pointed in the screw for purposes of ease in fabrication. The general configuration of the flute 42 can be best seen in the front elevation shown in Figures 2, 5, 7 and 10. It has an increasing depth and width as it extends up the work-penetrating portion in the direction of the shank.

The second segment 46 of the work-penetrating portion 36 is best viewed in Figures 1 and 3 and includes a first portion 48 which extends from the tip 40 less than the full axial extent of the work-penetrating portion 36. The majority of this first portion 48 is parallel to the plane A—A. The lower extremity of the first portion 48 is rounded and blends into the rounded tip 40 to substantially complete the hemispherical tip configuration shown in this embodiment. A second portion 50 extends upwards and outwards from the upper limits of the first portion 48 to blend with the juncture of the work-penetrating portion 36 with the shank 34, preferably on a circle having a diameter greater than the minor diameter and less than the pitch diameter of the threaded portion of the shank. This second portion 50 is provided with at least one or more partial threads 52 which have the same hand as the shank threads. The pitch of these partial threads can be equal to or greater than the pitch of the shank threads.

As can be seen from this description, the work-penetrating portion 36 is unsymmetrical in relation to the axis of the shank when viewed along the plane A which is coincident with the axis, and is symmetrical when viewed perpendicular to this plane. Reference to Figure 1 reveals the unsymmetrical arrangement, while Figures 2 and 3 show the symmetry when the screw is rotated 90° in either direction. Further evidence of this is to be found in the end view shown in

Figure 4. The two edges 54, 56, formed at the juncture of the two segments, diverge outwards and upwards from the tip 40 for the purposes best set forth hereinafter.

Referring now to Figures 5 to 10, which show the operation, this screw is inserted by an operator into an undersize prepunched aperture 60 in a sheet metal panel 58. It has been found that the screw is usable in thicknesses of panel varying from less than 0.015 inches to in excess of 0.050 inches. Preferably the aperture diameter is substantially less than the pitch diameter of the thread on the shank 34. Rotation of the screw by the operator engages the flute 42 with the edge wall of the aperture 60. As rotation continues, the flute 42 draws the screw downwards into the aperture and the flute 42 also tends to deflect the edge of the aperture downwards. The symmetrical diverging edges 54, 56, at the juncture of the two segments of the work-penetrating portion, extrude the sheet material downwards as shown in Figures 7 to 9. The extrusion 64 continues to be shifted downwards as the screw rotates. When the penetration of the screw reaches the second portion 50, the partial threads 52 bite into the extrusion 64 and assist the flute 42 in drawing the screw downwards. The diverging walls 54, 56 continue to expand the extrusion radially outwards and the partial thread or threads 52 draw the screw into a position where the lowermost threads 68 on the shank 34 engage the walls of the extrusion to form a thread and continue to pull the screw into associated relationship with the panel 58. The screw 30 is a hardened screw which permits the threads 68 to form their own impression on the inner wall of the extrusion 64 and to bring the screw into final fastened relation to the panel 58. In situations where the screw is utilized with porcelain-coated materials, the heat treating of the screw substantially eliminates wear, galling or deformation during the passage through the materials.

Preferably, a screw of the type described above is driven by a power tool. It has been found that the rotation of the screw has a spinning action on the metal, which creates heat, and this helps to provide the maximum amount of extrusion, and strong close mating of the male threads of the screw with the formed female threads in the extrusion. The extrusion of material increases the area available for engagement and thereby adds to the number of threads engageable by the screws in the panel. This provides an increase in the pull-out strength and stripping torques. The cooling down of the extruded hole with its initially formed close mating thread causes it to shrink around the screw thread, so providing an even closer mating fit with a higher prevailing torque for removal, which is a major deterrent to loosening through vibrators.

If desired, the clamping face of the head 32 can be provided with "torque robbers", not shown, such as nibs of the type found in our British Patents 888,308 and 888,309. In the thinner sheet materials such "torque robbers" assist in building up torque when the head reaches its clamping position so that the automatic clutch in the driver will disengage prior to stripping the threads formed in the panel. When holes in heavier materials such as those over 0.050 inches are punched, because of the greater clearances between the punch and die, the holes vary from the smaller and more accurate close grain punch size at the top to the larger and more irregular coarse grain at the far side or die side. This coarse grain generally is weakened and produces threads which vary considerably in strength when used with standard gimlet point screws. By providing the optimum hole size, the screw prepares the hole by moving material downwards and strengthens the weaker coarse grained areas. Since more heat is created in the extruding of heavier metals, the formation of threads become easier. When the fastening is accomplished and the panel cools down, a greater shrinkage occurs around the screw threads providing a more intimate fit of the components. This increases the break-away torque considerably and provides a high prevailing loosening torque, thus adding to the sustained holding capabilities.

An additional advantage of the screw is found in the rounded tip. Service men often complain about screws cutting or scratching the skin on hands and arms where insufficient space and clearances are lacking in equipment whereas the rounded end of this screw eliminates much of this problem.

The main advantage, however, of the screw described above is that thicknesses of sheet material used may be reduced, since the screw by extrusion increases the area available for contact, which provides a greater number of threads in engagement and hence increases the holding power of the screw. The reduction of a single gauge of material thickness where large quantities of sheet metal are used may often provide huge savings, many times the cost of the screw.

Referring now to Figures 11 to 17, a screw of the type described hereinabove is best formed by cold heading a blank 70 (Figure 17) so as to have a head 32, an unthreaded shank 72, and a pilot portion 74 connected to the shank by a tapering section 76. This blank is then forged between a pair of opposed pinch pointing jaws, of the type shown in Figures 11 to 13 and 14 to 16, in the normal accepted practice. The cavity of one jaw 78 bears an impression which is the mirror image of one segment of the work-penetrating portion 36. In the particular in-

stance illustrated, the jaw shown in Figures 11 to 13 would form the second segment having its two portions 48, 50, as represented by the forging portions 80 and 82 respectively. The partial thread 52 would be formed by the male impression 84. The second jaw 79 shown in Figures 14 to 16 would form the first segment 38 and its associated flute 42 by means of the portions 86 and 88 respectively. After the work-penetrating portion 36 has been formed on the tapering section 76 and pilot portion 74, the unthreaded shank 72 is thread-rolled to provide the threaded shank 34. The forging of a screw point by means of pinch-pointing jaws is an automatically-fed rapid process which is known in the art. The screw is then heat-treated in recognized fashion and is ready for use. The forging of the point permits practical manufacture of a fine machine screw with a gimlet type point in an economical fashion.

The plane of meeting and parting of the jaws 78, 79 may coincide with the plane A—A coincident with the axis of the screw, or may be offset a small distance. A slight offset ensures that any roughness on the screw along the plane of parting does not coincide with the edges 54, 56 which lie in the plane A—A, at the greatest width of the screw as seen in Figures 2, 3 and 4.

It has also been found that a straight shank blank can be used as well as the blank shown in Figure 17.

A second embodiment of the present invention is shown in Figures 18 to 20 wherein similar parts bear similar numerals with the addition of the suffix "*a*". This is a self-drilling screw. In this second embodiment the first segment 38*a* of the work-penetrating portion 36*a* is substantially identical to the previous embodiment except that the lower portion is defined not by a smooth curvilinear surface but rather by a semi-pyramidal shape which gives two diverging substantially flat surfaces 90 and 92. The portion 96 above the spiral flute 42*a* is generally curvilinear as it was in the first embodiment.

The major change in this embodiment takes place in the second segment which includes a first portion 100 which falls on the axis of the screw. Portion 100 is preferably substantially flat but for certain applications may be slightly concave in a horizontal section. An intermediate portion 102 is axially spaced from the rounded tip 40*a* and is radially displaced from the axis of the screw. A second portion 104 extends outwards and upwards from its juncture with the portion 102 to blend into the shank 34*a*. One or more partial threads 52*a* are preferably impressed therein for the same purposes as the threads 52 in the first embodiment. The axial extent of the first portion 100, from the tip 40*a* to the second portion 102, is substantially equal to or in excess of the thickness of the material with which this screw is to be utilized. The flat surfaces 90 and 92 meet the portion 100 to form sharp lower portions of the side edges 54*a*, 56*a*. It has been found that such a screw when rotated by a power driver will drill a small aperture in sheet material by a cutting action similar to that described in our British Patent No. 1,060,807, and will then operate in the same fashion as the previously described embodiment by drawing the thin material downwards into an expanded extruded aperture, whereby greater thread engagement can be obtained by the threaded shank 34*a*. The flat surfaces 90 and 92 meet at a further sharp edge 94 which assists the extrusion process.

It should be noted that the semi-pyramidal shape of the first segment is not a necessity for utilization of this screw as a self-driller. The device will work equally well if the first segment is curvilinear in horizontal section, as in the first embodiment, provided the portion 100 is present and hence the lower portions of the side edges 54*a*, 56*a* are sharp.

It has been found that, by making the first portion 100 in the second embodiment concave away from the axis, a satisfactory self-drilling wood screw point is developed.

A third embodiment of the present invention is shown in Figure 21 wherein similar parts will be designated by similar numerals with the addition of the suffix "*b*". The work-penetrating portion is substantially identical to the first embodiment described in that it includes a first segment 38*b* having a spiral flute 42*b*. The second segment 46*b* has, at the juncture of its first portion 48*b* and its second portion 50*b* a depression 110, the basic function of which is to move material during the forging operation into and for purposes of filling out the first segment 38*b*. Partial threads 52*b* may be provided not only in the second segment but in the first segment as well, to assist in pulling the screw into the extruded work piece aperture.

Each of the embodiments described hereinabove permits the screw to enter a radically undersized hole, and without undue or unreasonable axial pressure to draw itself into that hole, all the while enlarging the hole by a spinning and extruding action to suit the threads on the shank following the work-penetrating portion. Normally, 15 to 20 pounds of axial pressure, which is identical to the force required to keep a "Phillips" (Registered Trade Mark) driver bit engaged in a screw recess during driving, is sufficient to cause these new screws to function properly. Laboratory tests show that a number 12 screw (0.216 inches O.D.) embodying the invention, when used with sheet metal 0.032 inches thick having 0.150 inch drilled holes, can be driven with a maximum drive torque of 14 in. lbs. and in the process extrude the material thickness from the said

0.032 inch to 0.074 inch. It is obvious that the pull-out resistance is increased due to increased thread contact. In comparison, a number 12 single-slot thread-cutting screw was tested in sheet metal 0.032 inches thick with 0.150 inch drilled holes. The point would not enter the material until the hole had been increased from 0.150 to 0.171 at which size the drive torque was 20 in. lbs. or 57% harder to drive than a screw embodying the invention. A single-slot thread-cutting screw two sizes smaller than the number 12 screw embodying the invention (a number 10 type 1) drove at 11 in. lbs. or nearly as great as the 14 in.lbs. experienced with the screw embodying the invention. Thus, a heavier, stronger screw embodying the invention can be used in thin sheet materials with machine screw threads which previously were impossible to use in this type of application.

WHAT WE CLAIM IS:—

1. A self-tapping screw having a head, a threaded shank, and a work-penetrating portion at the end of the screw opposite to the head, the work-penetrating portion having two integral dissimilar segments falling on opposite sides of a plane coincident with the axis of the screw, the first segment being substantially one half of a tapering prolongation of the shank, terminating in a tip, there being a helical flute impressed in this first segment, this flute being of the same hand as the shank threads, and the majority of the flute being of greater pitch than the shank threads, the second segment having a first portion which extends from the tip of the work-penetrating portion through a distance less than the axial extent of the work-penetrating portion, and being substantially on or parallel to the said plane coincident with the axis of the screw, the second segment having a second portion which blends radially outwards and towards the head to the juncture of the work-penetrating portion with the shank, whereby the work-penetrating portion is substantially symmetrical when viewed perpendicular to the said plane, and is unsymmetrical in relation to the axis of the shank when viewed along that plane.

2. A screw as claimed in claim 1, wherein the helical flute has a non-uniform pitch which is substantially equal to the pitch of the shank threads at the juncture of the work-penetrating portion and the shank.

3. A screw as claimed in claim 1 or claim 2, wherein the second portion of the second segment has partial threads having the same hand as the shank threads.

4. A screw as claimed in any of claims 1 to 3, wherein the tip of the work-penetrating portion is hemispherical.

5. A screw as claimed in any of claims 1 to 4, wherein the second segment has its first portion spaced from the axis of the screw.

6. A screw as claimed in claim 1, wherein the second segment has its first portion on the said plane, an intermediate portion parallel to but spaced from the plane and its second portion blending outwards to the shank.

7. A screw as claimed in claim 6, wherein the first portion is concave in a horizontal section.

8. A screw as claimed in claim 6, wherein the second portion includes partial threads.

9. A screw as claimed in any of claims 1 to 8, wherein the helical flute has an increasing depth and width as it extends up the work-penetrating portion in the direction of the shank.

10. A screw as claimed in any of claims 1 to 9, wherein the first portion of the second segment has a depression.

11. A screw as claimed in claim 10, wherein at least one partial thread of the same hand as the threads on the shank is imposed on the portion of the first segment between the helical flute and its juncture with the shank.

12. A method of forming a self-tapping screw including heading a blank to provide a head and shank, the shank having a reduced pilot portion at its free extremity, forging the pilot portion between opposed dies to provide a work-penetrating portion as defined in any of claims 1 to 11, and then thread-rolling the shank.

13. A method as claimed in claim 12, wherein the screw is heat-treated subsequent to thread rolling.

14. A screw as claimed in claim 1, substantially as described with reference to Figures 1 to 10, Figures 18 to 20, or Figure 21 of the accompanying drawings.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1971. Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1249725 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig.1

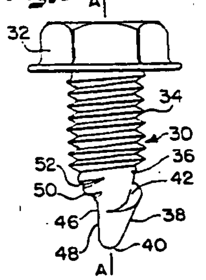


Fig.2

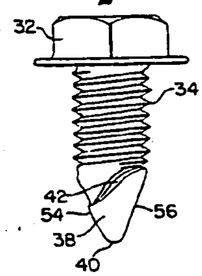


Fig.3

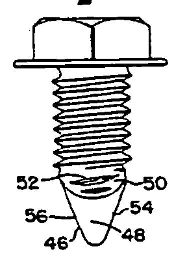


Fig.4

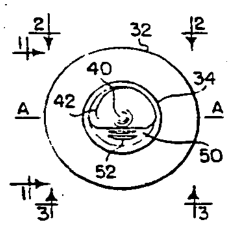


Fig.5

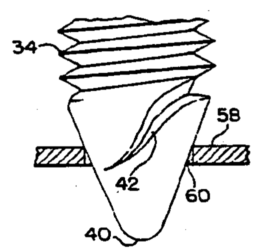


Fig.6

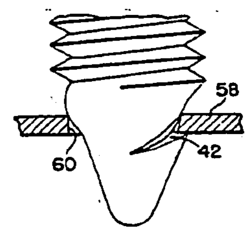


Fig.7

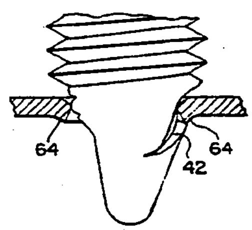


Fig.8

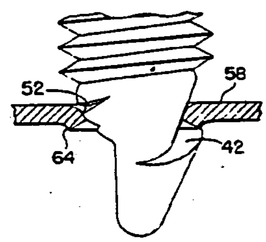


Fig.9

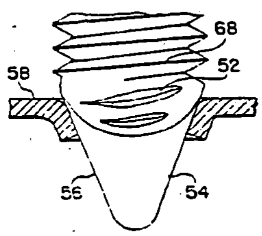


Fig.10

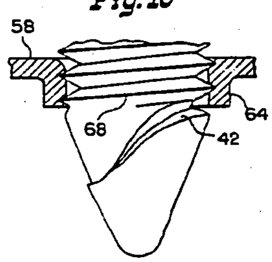

Fig.11

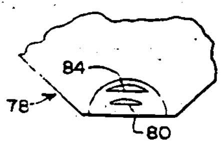


Fig.12

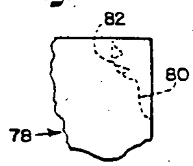


Fig.13

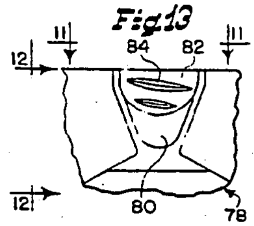


Fig.14

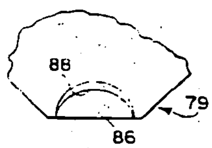


Fig.15

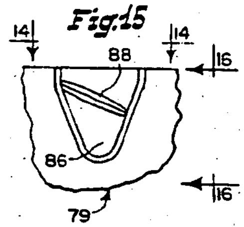


Fig.16

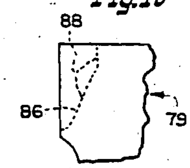


Fig.17

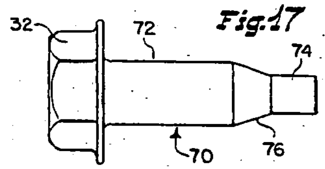


Fig.18

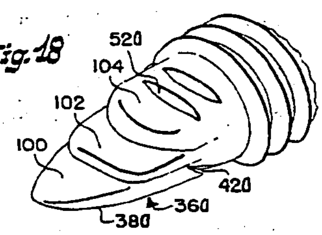


Fig.19

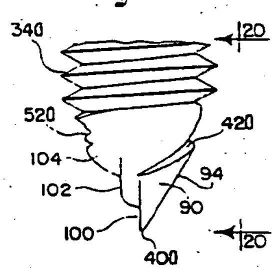


Fig.20

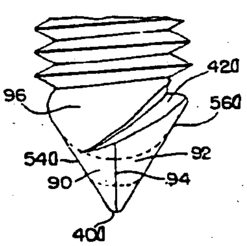


Fig.21